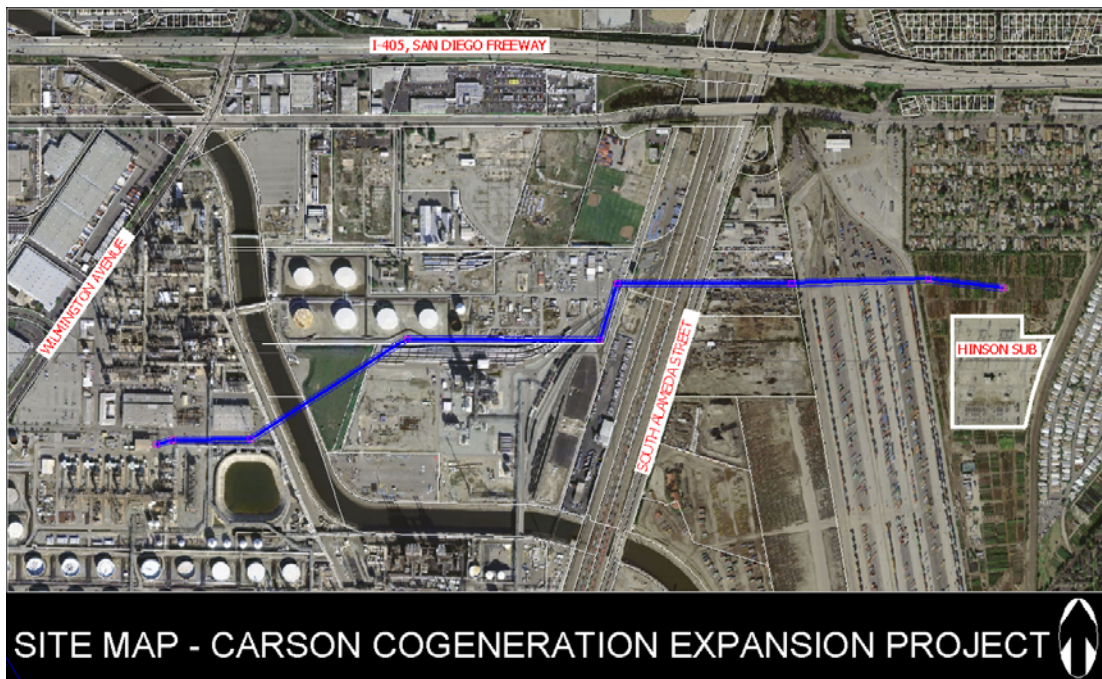


Appendix B

Transmission Line Analysis

The Watson Cogeneration Company (Applicant) submits this Application for Certification for its Watson Cogeneration Steam and Electrical Reliability Project (Project), formerly known as the Carson Cogeneration Expansion Project. All references in Appendix B, Transmission Line Analysis, to the Carson Cogeneration Expansion Project and the Carson Cogeneration Plant now apply to the Project and the Watson Cogeneration Facility, respectively.

BP ALTERNATIVE ENERGY, NORTH AMERICA, INC.
CARSON COGENERATION EXPANSION PROJECT
TRANSMISSION LINE ANALYSIS



**BP ALTERNATIVE ENERGY, NORTH AMERICA
CARSON COGENERATION EXPANSION PROJECT**

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A. SUMMARY

The BP Alternative Energy plans to expand the generation capacity at the existing Carson Cogeneration Plant by one of three choices: 80-MW, 250-MW, or 500-MW. An expansion by any amount has an impact on the double-circuit 230-kV transmission line currently used to transmit the energy to Southern California Edison at their Hinson Substation. This analysis first determines the residual capacity of the existing line, for both maximum plant output and for normal operating conditions, then evaluates the availability of any residual capacity for each level of proposed expansion. If insufficient residual capacity is available in the existing transmission line a solution is recommended to provide the least-cost alternative which would allow the desired increase in generation capacity.

The existing cogeneration plant has a nameplate rating of 385-MW. This analysis determined the capacity of the transmission line connecting the cogeneration facility to Southern California Edison exceeds the plant nameplate rating by nearly 130%. The maximum normal transmission line rating is 878-MW with both circuits in operation and 439-MW with only one circuit. With both circuits in operation, which is assumed to be the normal operating condition, the maximum expected annual cost of line losses is \$83,500 in 2008 dollars.

The 80-MW of additional capacity will load the existing transmission line 53% of capacity with both circuits in operation: or 106% with only one circuit. This calculation assumes the transmission line is required to transmit the maximum plant output to SCE. Under the conditions normally encountered the refinery, co-located with the cogeneration facility, will consume an average of 70-MW and the plant will operate with an average plant capacity factor of 89%. Applying these two conditions to the formula provides a Normal Transmission Line Operation requirement 344-MW with the added 80-MW of plant capacity. Under these conditions the existing transmission line would be loaded to 39% of maximum normal capacity with both circuits and 78% with one circuit. The annual cost of line losses, in 2008 dollars, will increase by 46% based on the new maximum plant rating of 465-MW.

The proposed expansion by 250-MW would also be possible with no modification to the existing transmission line assuming double-circuit operation. 500-MW of additional generation capacity would not be possible as the maximum plant output would load the conductor beyond the maximum normal rating of the conductor. With just one circuit in operation production would have to be curtailed by 45% for the 250-MW expansion and by over half for the 500-MW expansion. Losses would increase significantly as well: 189% for the 250-MW expansion and 462% for the 500-MW expansion.

In order to avoid significant reconstruction costs but provide a means to mitigate a portion of the required cogeneration curtailment and reduce the cost of line losses, a conductor upgrade is suggested to benefit the 250-MW or 500-MW expansion. The conductor recommended by this study is 1210 kcmil ACCC 'CARDINAL/ACCC' which has a reduced strength-to-weight ratio and a smaller overall conductor diameter. The estimated cost of replacing the conductor is \$836,000, in 2008 dollars.

With this conductor replacement the transmission line would be capable, with both circuits in operation, of transmitting the maximum cogeneration plant output to SCE. Some production curtailment is still required for single-circuit operation but is reduced to 34% for the 250-MW expansion and 52% for the 500-MW expansion under normal operating conditions. The increase in current line loss costs is also reduced to 147% and 381% for the proposed 250-MW and 500-MW expansion, respectively.

B. INTRODUCTION

The Carson Cogeneration Facility (Plant), located in Carson, California and originally constructed by ARCO Petroleum Products was originally designed for a maximum normal power output of 385-MW. Energy produced by the Plant is transferred to the Watson Switchyard where part of the energy is transferred to the refinery with the remaining energy distributed to Southern California Edison's Hinson Substation via a 230-kV, double-circuit transmission line. The transmission line and Hinson Substation are currently owned and operated by Southern California Edison (SCE). The Plant is currently owned by BP Alternative Energy, North America.

The transmission line is a double-circuit, single-conductor line operated at 230-kV. All conductors are 1033.5 kcmil ACSR "ORTOLAN" and are supported by lattice steel transmission towers. Total line length is 1.6 miles from Watson Switchyard to Hinson Substation. The line plan and profile drawings and structure drawings were not made available for this analysis.

TriAxis Engineering has been contracted to analyze the impacts to this transmission line if the existing Plant expands maximum normal capacity by one of three choices: 80-MW, 250-MW, or 500-MW. This analysis will focus on the individual levels of planned expansion to determine if the transmission line has the capacity to transmit the added load, to understand the implications for operations and maintenance of the transmission line, and to evaluate the transmission line economics resulting from the planned expansion. If the existing transmission line is inadequate for any of the three options, a solution will be proposed based on sound engineering judgment and economics. Detailed design options will not be developed as part of this analysis.

C. EXISTING COGENERATION PLANT AND TRANSMISSION LINE

The existing Plant was constructed with a maximum normal power output of 385-MW. A portion of the energy generated is consumed by the refinery co-located with the Plant. The transmission line transmits the remaining energy to SCE to be sold on the open market. Based on this model, the existing transmission line will be evaluated with the results used as a comparison baseline for each level of proposed expansion.

Table 1 summarizes the existing Plant operational profile for a ten month period beginning January, 2007. It is conservatively assumed the Plant can remain 100% operational when the refinery is drawing no energy from the Watson Switchyard. This assumption is the foundation for the baseline values used to analyze the normal maximum capacity of the existing SCE transmission line.

Table 1. Cogeneration Facility Performance Data				
	Maximum from 2007 Performance Data	Minimum from 2007 Performance Data	Average from 2007 Performance Data	Baseline Data for Trans. Line Analysis
Maximum Normal Cogen Plant Capacity	416-MW	238-MW	335-MW	385-MW
Average Power to Refinery	86-MW	69-MW	78-MW	70-MW
Average Cogen Plant Capacity Factor	95%	81%	89%	100%
Power Transmitted to SCE	339-MW	226-MW	271-MW	315-MW
Maximum Normal Trans Line Capacity				385-MW

According to the original design documents (Attachment A) the transmission line is to have a maximum normal capacity at 1160 amps per circuit. Common design methodology suggests this capacity rating is likely to be that which will produce a conductor temperature of 212°F. Calculations performed for this analysis confirm this to be approximately correct (Attachment B). This is an important distinction as this often becomes a limiting condition for conductor capacity based on sag at high temperatures. Table 2 summarizes the designed normal capacity ratings for the existing transmission line along with the calculated maximum normal rating for energy transfer per circuit and for the line. From this data, and the data in Table 1, it is apparent the existing transmission line is more than

adequate to accommodate the maximum nameplate Plant rating of 385-MW with both circuits in operation or with a single-circuit in operating.

Table 2. Existing Transmission Line Ratings				
	Stated Design Capacity (amps)	Calculated Conductor Temperature ₁ (°F)	Calculated Single-circuit Capacity ₂ at 230-kV (MW)	Calculated Line Capacity (2 Circuits Installed) (MW)
Maximum Normal Rating	1160	212	439	878
1. Latitude = 33.8°N, Elevation = 50ft., Atmosphere is clear, Local Sun Time = 11am, Emissivity = 0.5, Absorptivity = 0.5, Ambient Temperature = 104°F, Wind Speed = 2 fps 2. Power Factor = 0.95				

Single-circuit operation is important to this analysis as it is often necessary to de-energize a circuit for routine repairs and maintenance or to de-energize one of the circuits to clear a fault on the line. In either case, the one remaining circuit on the existing transmission line should be capable of transmitting the maximum normal Plant output to minimize any curtailment of production and resulting loss of revenues. The data in Table 2 proves the existing transmission line is capable of transmitting the maximum normal Plant output with only one circuit in operation.

The annual cost of losses for the existing transmission line is estimated at \$83,500 with both circuits in operation (Calculations in Attachment C). When the energy consumed by the refinery and the average plant capacity factor is included in the calculation, which more closely mimics daily operations, the energy transmitted to Hinson Substation is calculated to be 273-MW, reducing the estimated annual cost of losses to \$44,700. These estimates for the cost of losses, and future estimates in this analysis, assume the break-even cost of production is \$50/MWH. The annual cost of losses in 2008 dollars is used here to preclude any assumptions on inflation or financing costs.

D. 80-MW EXPANSION

Table D.1 Comparison of 80-MW Expansion to Existing Plant Capacity for Maximum Transmission Line Operation						
			Double-circuit Operation		Single-circuit Operation	
	Maximum Normal Plant Rating (MW)	Maximum Normal Ampacity Required ₁ (amps)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)
Existing	385	1017	44%	\$83.5k	88%	\$166.0k
Planned 80-MW Expansion	465	1229	53%	\$121.8k	106%	\$243.6k
1. Assumed power factor = 0.95 2. Assumed break-even cost of production = \$50/MWH						

The calculations summarized in Table D.1 demonstrate the ability of the existing transmission line to accommodate the proposed 80-MW expansion. As shown, the additional 80-MW, when added to the maximum normal plant rating, will produce 1229 amps which is just 53% of the total line capacity with both circuits in operation. If just one circuit is operable, due to maintenance or other reasons, the maximum normal plant rating will load the single-circuit to 106% of the maximum normal line rating. This is predicted to increase the high-temperature sag approximately fourteen inches beyond that expected for the maximum normal circuit rating. If this increase in sag is unacceptable based on available clearance or other issues, Plant production must be curtailed when only one circuit is operational.

Line losses will increase by approximately 46%, for both double-circuit and single-circuit operation, if the total normal maximum plant capacity is transmitted to Hinson Substation. This assumes the plant operates continuously at 100% capacity and no energy is consumed by the refinery. Table D.2 shows revised results which assume the average plant capacity factor of 89% and continuous refinery consumption of 70-MW. In this case the additional 80-MW of generation capacity increases the cost of losses by 59% since all of the added capacity (71-MW accounting for the 89% plant capacity factor) is transmitted to SCE.

Table D.2 Comparison of 80-MW Expansion to Existing Capacity for Normal Transmission Line Operation						
			Double-circuit Operation		Single-circuit Operation	
	Maximum Normal Plant Rating (MW)	Maximum Normal Ampacity Required ₁ (amps)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)
Existing	273	720	31%	\$44.7k	62%	\$89.4k
Planned 80-MW Expansion	344	909	39%	\$71.0k	78%	\$142.0k
1. Assumed power factor = 0.95 2. Assumed break-even cost of production = \$50/MWH						

E. 250-MW EXPANSION

Table E.1 Comparison of 250-MW Expansion to Existing Plant Capacity for Maximum Transmission Line Operation						
			Double-circuit Operation		Single-circuit Operation	
	Maximum Normal Plant Rating (MW)	Maximum Normal Ampacity Required ₁ (amps)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)
Existing	385	1017	44%	\$83.5k	88%	\$166.0k
Planned 250-MW Expansion	635	1678	72%	\$241.8k	145%	n/a
1. Assumed power factor = 0.95 2. Assumed break-even cost of production = \$50/MWH						

As with the planned 80-MW expansion, the double-circuit operation of the transmission line has the capacity to transmit the full maximum normal output from the Plant to SCE. Restrictions will be required, however, to operate the transmission line with a single-circuit when the plant is at maximum operation. In this case, with only one circuit energized, the transmission line will be operating at 145% of capacity.

For the planned 250-MW expansion, the cost of losses will increase, assuming double-circuit operation, 100% plant capacity factor and no load consumed by the refinery, from \$83.5k to \$241.8k: an increase of 190%. As discussed before, it is more likely for the plant to operate at the average plant capacity factor of 89% and for the refinery to consume the average 70-MW. These revisions are summarized in Table E.2 where the increase in line losses is now up to nearly 230%.

Table E.2 Comparison of 250-MW Expansion to Existing Plant Capacity for Normal Transmission Line Operation						
			Double-circuit Operation		Single-circuit Operation	
	Maximum Normal Plant Rating (MW)	Maximum Normal Ampacity Required ₁ (amps)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)
Existing	273	720	31%	\$44.7k	62%	\$89.4k
Planned 250-MW Expansion	495	1308	56%	\$147.0k	113%	\$294.0k
1. Assumed power factor = 0.95 2. Assumed break-even cost of production = \$50/MWH						

Also noted in Table E.2 is the fact that, under normally expected circumstances, the transmission line capacity is nearly capable, under both double-circuit and single-circuit operations, of transmitting the necessary energy to SCE. If this option is pursued, restrictions will be required on Plant operations to reduce the output in situations where only one circuit is in operation.

The operational restrictions can be removed, given the 250-MW expansion, if the existing conductor is replaced with a composite-core, shaped aluminum conductor. The composite-core effectively reduces the ratio of strength to weight indicating the proposed conductor will have design tensions similar to, or less than, the existing conductor. The shaped aluminum strands reduce the overall conductor diameter for a given circular mil rating, lowering the transverse loading imposed by wind. These two characteristics make it possible to use the existing lattice steel towers with no modification. Table E.3 compares the existing 1033.5 kcmil ACSR to 1210 kcmil ACCC, the logical choice for this situation.

Table E.3 Comparison of 1033.5 kcmil ACSR to 1210 kcmil ACCC		
	Existing Conductor ₁	Proposed Conductor ₂
Conductor Codeword	"ORTOLAN"	"CARDINAL/ACCC"
Conductor Size	1033.5 kcmil ACSR	1210 kcmil ACCC
Overall Diameter	1.212 in	1.196 in
Unit Weight	1.164 lbs/ft	1.228 lbs/ft
Ultimate Tensile Strength	27700 lbs	37100 lbs
Maximum Normal Operating Temperature	212 °F	212 °F
Conductor Ampacity, Maximum Normal Rating	1160 amps	1250 amps
Expected Maximum Sag, Maximum Normal Rating	31.7 ft	31.8ft
1. Southwire ACSR 2. Composite Technology Corporation ACCC		

As shown in Table E.3, the maximum normal operating temperature of the 1210 kcmil ACCC is assumed to match the existing 1033.5 kcmil ACSR. An additional benefit of this proposed conductor, due to the composite core technology, is the ability to operate the conductor at a temperature much higher than traditionally allowed by ACSR thereby increasing the capacity of the conductor. With no knowledge of the existing lattice tower heights or clearance requirements, this analysis cannot predict any benefits achieved by high-temperature operation but believe it prudent to mention the possibility for future study if necessary.

Table E.4 Comparison of 250-MW Expansion to Existing Plant Capacity for Maximum Transmission Line Operation, Conductor Replaced with 1210 kcmil 'CARDINAL/ACCC'						
			Double-circuit Operation		Single-circuit Operation	
	Maximum Normal Plant Rating (MW)	Maximum Normal Ampacity Required ₁ (amps)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)
Existing	385	1017	44%	\$83.5k	88%	\$166.0k
Planned 250-MW Exp., Cond. Replaced	635	1678	67%	\$206.6k	134%	\$413.2k
1. Assumed power factor = 0.95 2. Assumed break-even cost of production = \$50/MWH						

Table E.5 Comparison of 250-MW Expansion to Existing Plant Capacity for Normal Transmission Line Operation, Conductor Replaced with 1210 kcmil 'CARDINAL/ACCC'						
			Double-circuit Operation		Single-circuit Operation	
	Maximum Normal Plant Rating (MW)	Maximum Normal Ampacity Required ₁ (amps)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)
Existing	273	720	31%	\$44.7k	62%	\$89.4k
Planned 250-MW Exp., Cond. Replaced	495	1308	52%	\$125.5k	105%	\$251.0k
1. Assumed power factor = 0.95 2. Assumed break-even cost of production = \$50/MWH						

Tables E.4 and E.5 provide summaries similar to those in Tables E.1 and E.2 assuming the conductor has been replaced with the 1210 kcmil ACCC. Assuming the transmission line must withstand the total normal maximum output from the Plant, even the proposed 1210 kcmil ACCC would be loaded to 134% of the normal maximum rating. If, however, the line necessary line capacity is based on the normally expected maximum of 495-MW, which takes into account the average plant capacity factor and the energy consumed by the refinery, the transmission line would be loaded to 105% of the normal maximum rating: a very manageable situation using operational restrictions for the Plant output.

Comparing the first year cost of losses before and after the conductor replacement, for the planned 250-MW expansion, shows an annual savings of \$35k for maximum normal operation and \$22k for the normally expected operation. This savings over twenty years, in net present value, is expected to be approximately \$214k. This savings must be compared to the net present value of the twenty-year cost to replace the conductor which is estimated at \$2.82M. This cost is summarized in Table E.6.

Table 6. Conductor Replacement Costs				
Hardware Retrofit				
	Unit Price (USD)	Quantity	Sub-Total (USD)	Total (USD)
Tangent Structures	\$30,000	1	\$30,000	
Angle Structures	\$32,000	3	\$96,000	
Double-Deadend Structures	\$60,000	2	\$120,000	
Deadend Structures	\$30,000	2	\$60,000	
Total Structural Cost				\$306,000
Conductor Change-Out				
Line Length			7073 ft	
Number of Circuits			2	
Added %-age for Sag/Waste			4%	
Conductor Fabrication & Delivery	\$8.00/ft	44140 ft	\$353,000	
Conductor Installation	\$4.00/ft	44140 ft	\$177,000	
Total Conductor Replacement Cost				\$530,000
Estimated Total Project Cost				\$836,000
Present Worth Construction Cost, 20-Year Life				\$2,872,000

F. 500-MW EXPANSION

Table F.1 Comparison of 500-MW Expansion to Existing Plant Capacity for Maximum Transmission Line Operation						
			Double-circuit Operation		Single-circuit Operation	
	Maximum Normal Plant Rating (MW)	Maximum Normal Ampacity Required ₁ (amps)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)
Existing	385	1017	44%	\$83.5k	88%	\$166.0k
Planned 500-MW Expansion	885	2338	101%	\$469.8k	202%	n/a
1. Assumed power factor = 0.95 2. Assumed break-even cost of production = \$50/MWH						

The proposed 500-MW expansion will exceed the capabilities of the existing transmission line at the maximum normal Plant rating whether considering double-circuit or single-circuit operation as shown in Table F.1. The first-year cost of losses for double-circuit operation increases by nearly \$400k. No results are shown for the loss costs under single-circuit operation due to the irrelevance. Table F.2 shows the results of factoring in the average plant capacity factor of 89% and the energy consumed by the refinery. Even with resulting reduction in energy to be transmitted to SCE, the transmission line is loaded to 82% of the normal maximum rating. Economic analysis for these conditions shows a slightly less drastic increase in the loss costs of approximately \$360k.

Table F.2 Comparison of 500-MW Expansion to Existing Plant Capacity for Normal Transmission Line Operation						
			Double-circuit Operation		Single-circuit Operation	
	Maximum Normal Plant Rating (MW)	Maximum Normal Ampacity Required ₁ (amps)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)
Existing	273	720	31%	\$44.7k	62%	\$89.4k
Planned 500-MW Expansion	718	1896	82%	\$309.2k	163%	n/a
1. Assumed power factor = 0.95 2. Assumed break-even cost of production = \$50/MWH						

The 1% overload under double-circuit operation at maximum plant capacity causes the conductor upgraded solution recommended for the 250-MW expansion to again be valid. The capacity gained, 68-MW for double-circuit operation, provides a reasonable operational margin for double-circuit operation. The losses for double-circuit operation are also reduced by approximately 15% at maximum transmission line operation and for normal transmission line operation. The analysis results, assuming the conductor is replaced, are summarized in Tables F.3 and F.4 for maximum and normal transmission line operations.

Table F.3 Comparison of 500-MW Expansion to Existing Plant Capacity for Maximum Transmission Line Operation, Conductor Replaced with 1210 kcmil 'CARDINAL/ACCC'						
			Double-circuit Operation		Single-circuit Operation	
	Maximum Normal Plant Rating (MW)	Maximum Normal Ampacity Required ₁ (amps)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)
Existing	385	1017	44%	\$83.5k	88%	\$166.0k
Planned 500-MW Exp., Cond. Replaced	885	2338	94%	\$401.3	187%	\$802.6k
1. Assumed power factor = 0.95 2. Assumed break-even cost of production = \$50/MWH						

Table F.4 Comparison of 500-MW Expansion to Existing Plant Capacity for Normal Transmission Line Operation, Conductor Replaced with 1210 kcmil 'CARDINAL/ACCC'						
			Double-circuit Operation		Single-circuit Operation	
	Maximum Normal Plant Rating (MW)	Maximum Normal Ampacity Required ₁ (amps)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)	Percent of Line Capacity	Annual Cost of Line Losses ₂ (USD)
Existing	273	720	31%	\$44.7k	62%	\$89.4k
Planned 500-MW Exp., Cond. Replaced	718	1896	76%	\$261.4k	152%	\$522.8k
1. Assumed power factor = 0.95 2. Assumed break-even cost of production = \$50/MWH						

With the recommended conductor replacement the transmission line rating satisfies requirements, whether at the maximum plant rating or under normal operating conditions, for double-circuit operation. If only one circuit is energized, however, some means of production curtailment will be required. If the maximum plant rating is assumed, production will need to be reduced by nearly half. For normal operation production will need to be reduced by approximately one-third. In either situation, careful planning must be done to ensure energy transmitted from the Watson Switchyard to Hinson Substation does not exceed the maximum normal line rating of 946-MW.